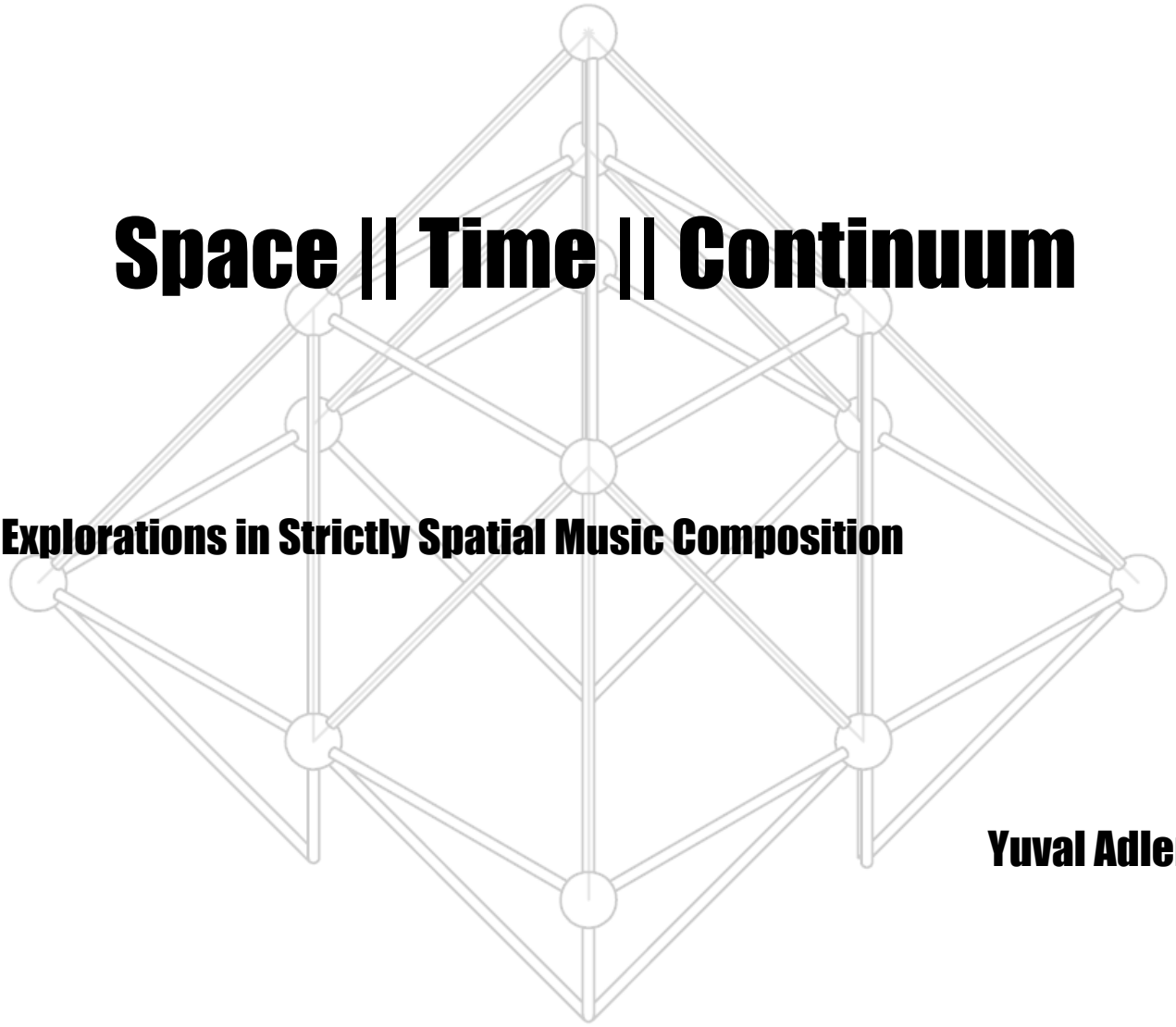


Space || Time || Continuum

Explorations in Strictly Spatial Music Composition

Yuval Adler

[Edited in 2022. This article was originally written in 2015 to describe an independent research-creation project I undertook right after my undergraduate degree and before applying for a master's degree. It remained as an unpublished draft until now. Other than editing for clarity, I have left this article almost entirely as it was. Though I am not always comfortable with the content and style, I wanted to publish this article as-is so that I can reference these thoughts as early points of departure for later work.]

Abstract

The overall purpose of this study is to challenge the notion of music as a strictly time-based art and show the existence of relatively uncharted creative space for music composition through the use of spatial organization of sound structures that forgo time as an important element, and to create initial contributions to the language and repertoire within this creative space to allow for further growth. This project makes no attempt to exhaust the creative space it reveals, but merely begin the discussion and lay a foundation for its future exploration and research. To further the understanding of the creative space presented, different methods will be used: I will suggest a definition of terms that might be used to talk about strictly spatial music compositions; I will share some early-stage field-work where I tried to shed light on the properties of some sonic materials through empirical observations; and I will present some small scale compositions that can act as examples for possible forms in the medium.

Setting up the sound files for one of the experiments. Bottom left are the portable speaker-players used in these experiments.

Theoretical Basis

Definition of Strictly Spatial Music

Characteristics:

- Music that is frozen in time and dispersed in space in such a way that the form of the composition does not exist in the former, but rather the latter.
- Unchanging sound sources in the psychoacoustic sense – i.e. loops limited to cycles at a range of 20 Hertz to 20 Kilo-Hertz – placed in specific spots in a fixed space as part of a composition.
- The experiencer can move within and\or around the composition freely to sense the structure.

Lacking a better name that addresses the loss of time as a structural element and the centrality of spatial construction in its stead, the term “strictly spatial music” will be used in this writing to refer to these primarily-spatial sound compositions.

Brief Historical Context

In an attempt to thinly outline the history of spatial thought in western music, I will give a handful of examples below. A full historical review would require work outside the scope of this undertaking. This is intended to give context within which to articulate some thoughts on the subject later in this article.

Space as a conscious element in musical performance has been present from the very early days of western music as can be seen in the antiphonal singing style, which places choirs at opposing sections of a church. Later the choirs would get completely independent parts, such as in Bach's polychoral *St. Matthew's Passion*.

The operatic banda tradition, starting perhaps with diegetic music played by Orpheus, such as in Monteverdi's opera named after the mythical musician, or Mozart's on-stage ensemble in *Don Giovanni*, has later evolved to off-stage ensembles, so vividly used in Verdi's operatic works, as an example. These off-stage parts were later employed in concert music as well, such as in Mahler's *Das klagende Lied*, where an entire orchestra plays off stage.

Marching bands have had a spatial element entwined in their music from the start. Hearing his father rehearse several separate marching bands at once has been said to give inspiration to Charles Ives when he composed his complex multi-layered musical works. In his masterpiece *Symphony No. 4* he uses spatially separated ensembles in one of the early examples of a conscious decision to use space as a parameter by a modern composer.

Later works by modern composers such as Stockhausen took this idea further. In *Gruppen* Stockhausen places three orchestral bodies to the right, front and left of the audience. Likewise experiments in space and music were also found in the works of his contemporaries Nono and

Berio, to name a few. Where in Berio's *Allelujah I* six orchestral bodies appear on stage, in *Allelujah II* he decidedly places the audience between five surrounding ensembles.

An important artistic work which tries to bridge the gap between music and spatial construction is *Poéme Electronique* of the 1958 World Fair. This grand undertaking by La Corbusier, Xenakis, and Varese builds a state-of-the-art architectural structure designed to house Varese's early electronic music piece performed on a complex array of speakers spatially dispersed in the building, while a before-then-unseen multi reel video art work was projected onto several surfaces of the structure, all in a synchronized light and sound show.

Along a different path, Marcel Duchamps, a groundbreaking artist who contemplated sound and its meaning, begins a journey that would help free sound from the musical limitations of that era. A musical piece by Duchamps from the 1910s-1920s, *Sculptur Musicale*, which is made up of nothing more than a few short lines of written instructions, reads: “musical sculpture. Sounds lasting and leaving from different places and forming a sounding sculpture that lasts.” A recording of an early rendition of the piece seems to interpret the instructions as relating to the lack of functional purpose of the notes in a conservative western musical sense, which are otherwise played on a piano in a fashion more in line with music over time than over space. But what starts here continues in the works of others.

Duchamps was an inspiration and colleague of John Cage, a pivotal character in 20th century music in general, and with relevance to the subject at hand in particular. Cage created works that questioned the very limits of sound and music. Works ranging from “action pieces” involving generating sounds with everyday objects, such as his 1959 *Water Walk*, to a piece made solely of timed silence some see as meant to pull attention to the constant background sounds of our surroundings - *4'33''*. In his quest to “free sound” Cage created pieces that later inspired a great many sound artists that work in a field growing in recent decades. Some going on to record places rather than events, either to use as musical building blocks or to present as is for the sake of appreciation of the everyday sounds which are around us. Others creating kinetic sculptures and performance works which deal with sound.

To name a recent example, *Composition for Two Floors and a Corridor* by Amnon Wolman from 2015 is an example of a sound art piece that tackles a large space, and fills it with various soundscapes that seem to be collected from subjective observations to create a large impressionistic experience. Recordings of synagogue prayers and electronically generated music loops coexist in this complex work that, while large in scale, seems deeply personal.

Difference from Previous Work in This Area

To establish what this project wishes to add to previous attempts at spatially aware compositions, I will compare the proposed definition for strictly spatial music as laid out earlier in this text and chosen pieces from the history of spatially aware musical compositions.

The first major difference that should be articulated is that strictly spatial music for this

project is defined as an object in space rather than an occurrence with a location. That is to say it is not an event taking place in time but rather a “frozen” object with form, as a statue or building might be. This places it apart from music ranging from antiphonal singing to *Allelujah II* by Berio and other pieces like it. In the kind of music I propose, the spatial component does not merely add a layer of complexity to sonic events occurring over time; rather, the spatial positioning of elements is the premier framework through which the form of the artwork should be discerned. Even brave attempts at combining music and physical structure such as *Poéme Electronique* do not achieve a unification of sound and space that would transcend the dominance of occurrence over time when evaluating the piece.

The definition given earlier also places my pieces presented later in this text as different from kinetic statues and performative works created by artists in recent decades. While it is true that the speakers in such a work vibrate much as parts of a kinetic statue might, the motion is not perceived by the experiencer of the piece, as it is faster than the frame rate of visual perception of distinct motion, and it is in the region of psychoacoustic perception of static sounds. The pieces here will not have anything happening, but rather a structure that simply is. This also puts them far away from performative works such as Cage's *Water Walk*.

A distinction from many other sound art pieces this project aims to have is to keep the works closer to the abstract and objective than the concrete and subjective. Many works in current sound art employ found sounds and real location recordings, and steering away from this will hopefully allow for the pieces to not rely on, or have the audience be distracted by, representations of realistic\unrealistic soundscapes. Locations will not be alluded to beyond those within the piece. The proximity of the recorded sound to the microphone or the relation between the volume of the source material compared to its reproduction will have no bearing. All this will free the composition to freely explore abstract geometric spatial relationships without added baggage.

Wolman's work discussed earlier comes to mind here. His quotation of real-life scenes and hints at an internal psychological realm to be explored take the focus away from the experience of the structure of sounds present in the space. This is not to say the overall composition present there is weak in any sense, but when looking at the combined installations present in *Two Floors and a Corridor*, the spatial structure they create is unclear and seems coincidental. A strictly spatial composition must be designed as a standalone whole with premeditated structure, and be able to convey this, rather than appear as a collection of installations.

Another important distinction from a large portion of sound art installations is that the pieces created within this framework do not require a set amount of time to experience. No long loops of recorded information are played, and no timed events happen in the pieces I present here. People may move through them as quickly or slowly as they wish, without necessarily missing out on any of the information presented.

The issue of all information being present at once raises another feature present in this

framework – there is a more direct relation between the written piece to the experienced one. While there is importance in the physicality of moving within the piece's structure, the entire piece can be read from a diagram, map, or model. It is far less simple to do this with pieces that attempt to deal with both time and space in a meaningful way.

All these differences may be blurred in time, as the new creative space is being explored further, but for now that which I haven't seen done in the field, strictly spatial music, is of greater interest to me, to allow for growth of the medium in uncharted directions.

Suggested Terminology – Elements of a Strictly Spatial Music Composition

Aside from the harmonic\timbral aspects of the sound, and the architectural\designed aspects of the space, are these basic elements of a strictly spatial music composition, which allow the sonorous and spatial aspects to be integrated:

- **Space**
- **Field**
- **Line**
- **Point**

These elements deal with how the sounds are organized in space, but also hide within them some issues that require attention regarding strictly spatial music.

Space

A space is the most complex element that can be present in a strictly spatial music composition. This is any structure that spreads in three dimensions and cannot be represented by any other element without losing critical information about its function. It holds within it and is built by the other elements.

A tetrahedron is a good example of a simple space within a composition. Four equidistant points cannot be represented with any less dimensions without losing the quality of all points being an equal distance from all the other points in the shape. It is important to note that this shape, as any other space within a strictly spatial music composition, only becomes meaningful if the experiencer can move within and/or around the shape freely in all three dimensions, otherwise it loses much of its three-dimensionality.

A collection of hills and valleys are not a good example of a space. While a third dimension may be important to capture the difference between a peak and a trough, the possible movement within this area can largely be described as happening on two dimensions (see field, below). The curvature of a field in such an example might be exaggerated to the limit of where it brings the third dimension significance again, but at that point it would be better described otherwise in a way that brings the three dimensional elements to light, such as breaking it up into geometric volumes.

Field

A field is made of sounds that span across a plane which is not necessarily flat, creating a sort of matrix between them. It can be constructed from points, lines, and two dimensional geometric sections, but only becomes meaningful as a field when free movement across its two dimensions is possible.

A flat floor dotted with sound sources emitting different sounds is a good example of a field that can be traversed freely, and where such movement bears meaning. A wide corridor where sounds only change along the axis of its length will not achieve this, and be better considered as a line instead (see below). This is also true for a group of intersecting pathways, who would be better categorized as lines which form a tree or net of decisions, rather than a plane to be explored freely on two axes.

Line

Each point in a line has a continuous link to the next/previous point, except for the edges, if edges exist. A line is not necessarily straight, and can emerge in a composition anywhere the experiencer has his movement confined within a path or single axis of movement.

It is important to note that this is the closest element to music over time, as it creates a “forward” and “backward” within it (or any other possible combination of two opposing directions.) A spatial composition that wishes to emphasize itself as such should attempt to stay clear of using lines too often, as these can be conceivably represented in other forms of music.

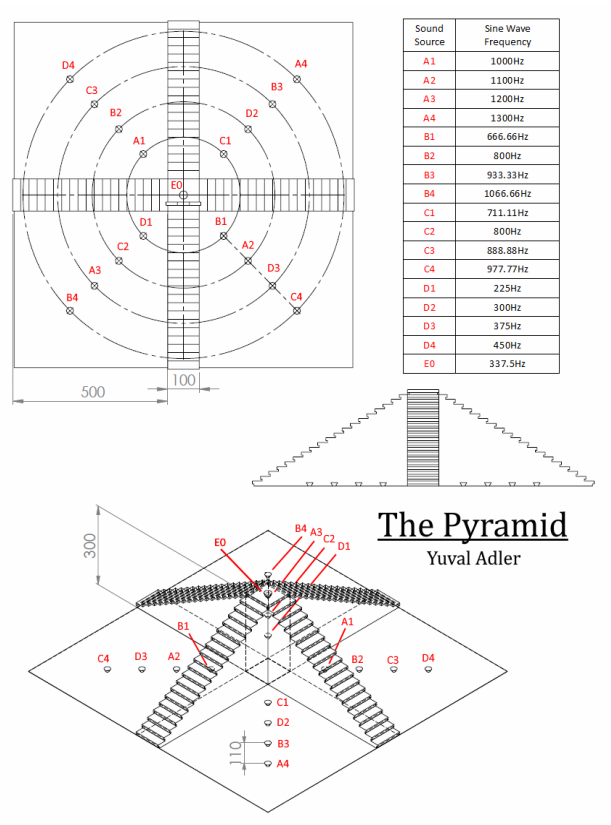
Point

The basic building block of all other elements. Can be used to mark a singular sound source, or a place where the listener is exposed to any number of sounds or lack thereof. Because the entire composition is built from points, the term should be used to mark those that are key or of interest.

Examples of Classifications

A spiral staircase is a bad example of a space, even though it seems to be defined in three dimensions. Since the experiencer can only travel the staircase in two directions, up and down the stairs, then this shape by itself would be better categorized as a line.

A quiet, isolated room within an external field of varying sounds is not a field in itself, no matter how large it is. This is because in terms of the information within that room, the room can be summed up as a point of silence with regards to the field around it, without the movement inside the room having any meaning musically.



Sound Source	Sine Wave Frequency
A1	1000Hz
A2	1100Hz
A3	1200Hz
A4	1300Hz
B1	666.66Hz
B2	800Hz
B3	933.33Hz
B4	1066.66Hz
C1	711.11Hz
C2	800Hz
C3	888.88Hz
C4	977.77Hz
D1	225Hz
D2	300Hz
D3	375Hz
D4	450Hz
E0	337.5Hz

An example composition, The Pyramid, *presented in more detail further on.*

Experimentation

A small set of experiments were carried out to learn about the physical, acoustical, and musical traits of spatially distributed sound sources. The goal was to get an initial hands-on experience with the material to inform early compositional attempts within the creative space of strictly spatial music.

Specifications

Scope

These experiments were limited to simple sounds – sine waves and white noise – that could be easily reproduced for later experiments and theoretically simpler to predict than complex sound sources. The size of each experiment's area was limited to small sections of several meters squared, as the intent was to explore these building blocks and define their limitations and traits, before basing a larger composition on them. Sound sources are unsynchronized to lower production costs, and the number of different sources limited to a small amount. A handful of experiments were carried out, as laid out below.

Tools

The tools for this experiment were chosen within budgetary restrictions, but that would still allow for maximum flexibility in execution. Small speaker-players that could be loaded with sound files on memory cards and charged allowed me to avoid dealing with wires. A small form factor allowed for easy distribution on any supporting physical constructions.

The speakers chosen were Music Z-12 portable MP3\WAV player-speakers with micro SD card reading capabilities. The technical specifications given by the manufacturer were as follows:

- Power Output: 3W
- Freq: 20Hz-20KHz
- S/N: 45dB

A quick test revealed that the frequency response range of the speaker was much more limited than that, giving a reasonably clear sine wave only above 200Hz, with some variance between speakers. With that in mind these specifications should be taken with a grain of salt. Each speaker was loaded with a 128MB micro SD memory card.

Sounds

The sounds loaded into the speakers were 44.1KHz 32bit .WAV format files with a recording of a continuous single sine wave, or filtered generated white noise, all at 0.8 of full single strength.

The sine waves and white noise recordings were generated using Audacity DAW. The noise was then filtered using the same software.

The specific frequencies and parameters used for each sound will be given in the description of each experiment done.

Location

Not having access to an acoustically controlled environment, after several attempts, an outdoor location was chosen where reflections were minimal and background noise was low enough to allow for details to be heard. It was an open space outdoor gym with padded flooring and several metal structures that did not seem to interfere with sound propagation.

The speakers being laid out in one of the early experiments attempted.

The Experiments

Experiment 1 – Missing Fundamental

This experiment was set up to allow observation of the psychoacoustic phenomenon of a phantom frequency – when high harmonic overtones of a missing fundamental allow for the fundamental to be heard even while physically absent – within the context of a strictly spatial music composition. The questions to be answered were whether or not the phenomenon would be reproduced with the tools available, whether or not the phenomenon would be reproduced with spatially dispersed overtones, and what could be learned that might inform future compositional attempts that try to utilize this phenomenon.

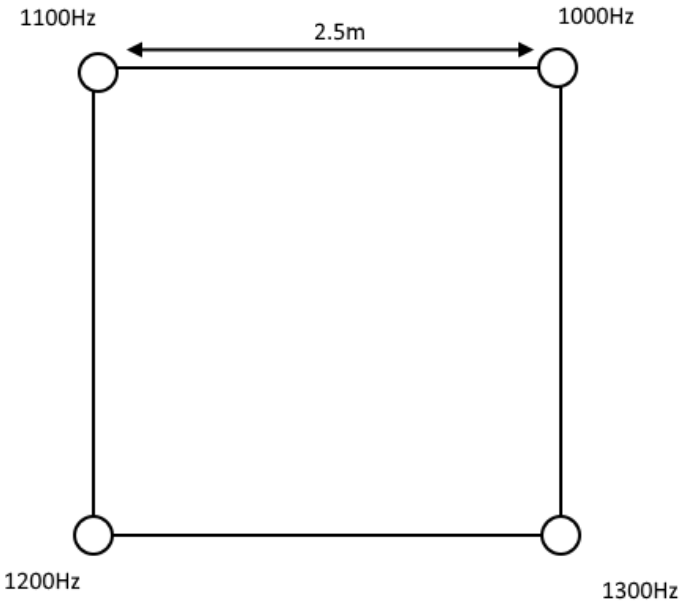
To test this, four speaker-players were loaded with single files of continuous sine wave recordings of the following frequencies:

- 1000Hz
- 1100Hz
- 1200Hz
- 1300Hz

These sine waves correlate to the tenth to thirteenth harmonics of the base frequency of 100Hz – which was the missing fundamental in this experiment.

Initially the speakers were clumped together and activated one after the other and in different groupings to see which overtones and in what amount gave rise to a phantom tone.

The four speakers, now all activated, were then laid out in a square on the ground, 2.5 meters across as shown in the diagram below, to allow for assessment of the phenomenon in a spatially dispersed situation.



The first part, when the speakers were clumped together, showed that the more overtones that participated in the “chord” the louder and clearer the fundamental was heard. Some combinations, such as 1000Hz and 1200Hz, gave rise to different phantom tones (in this case one of 200Hz).

In the second part of the experiment, where the sounds were distributed across the floor, the phenomenon was indeed still heard, and walking around different locations within and around the square did not eliminate the phantom tone. Interesting to note was the difficulty to differentiate separate sine wave locations; the sound sources were hard to pinpoint in space, except for when a position very close to one source was taken, where a large difference in volume between sounds was prominent.

Experiment 2 – Sinusoidal Beatings

This experiment was set up to allow observation of the phenomenon of acoustic beatings between close frequency sine waves – when waves close in frequency create a vibrato-like quality to the resultant wave that comes about through interference – within the context of strictly spatial music composition. The questions to be answered were whether or not the phenomenon would be reproduced with the tools available, whether or not the phenomenon would be reproduced with spatially dispersed sound sources, and what could be learned that might inform future compositional attempts that try to utilize this phenomenon.

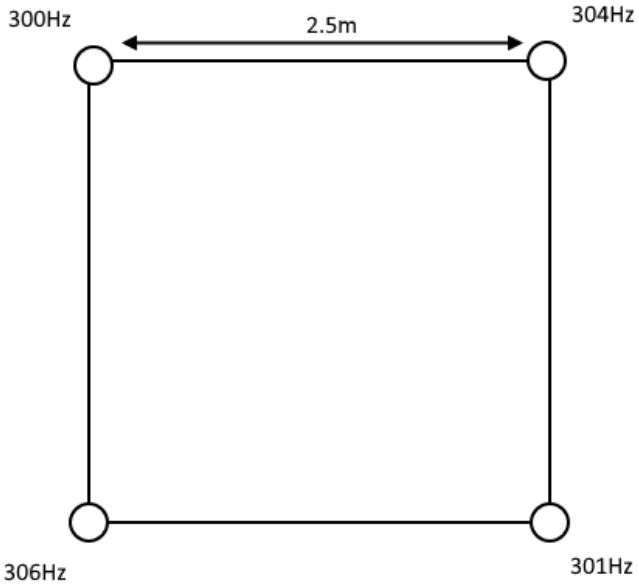
To test this, four speaker-players were loaded with single files of continuous sine wave recordings of the following frequencies:

- 300Hz
- 301Hz
- 304Hz
- 306Hz

These sine waves create a set of four waves such that no wave is the same difference in Hertz from any other wave when compared to any other pair of waves (through utilization of the characteristics of an order 4 perfect and optimal Golomb ruler). This was done to see if the different beatings created between each pair of waves were discernible from each other pair.

Initially the speakers were clumped together and activated one after the other and in different groupings to see which beatings were noticeable and to what degree.

The four speakers, now all activated, were then laid out in a square on the ground, 2.5 meters across as shown in the diagram below, to allow for assessment of the phenomenon in a spatially dispersed situation.



The first part, when the speakers were clumped together, showed that the beatings were easily heard for each pair of waves played together, but that playing more waves in conjunction made the base frequency much more prominent, and the beatings blurred into timbrel aspects that were harder to isolate.

In the second part of the experiment, where the sounds were distributed across the floor, the phenomenon was present, but as in the first part, the activation of all four speakers made the specific beatings hard to discern most of the time. When standing directly between two speakers, though, that pair's acoustic beating did become more prominent and identifiable.

Experiment 3 – Filtered Noise

This experiment was set up to allow observation of how noise functioned within the context of a strictly spatial music composition, as opposed to the sine waves tested so far. The questions to be answered were what difference was there between the sine waves tested thus far and what could be learned that might inform future compositional attempts that try to utilize this material.

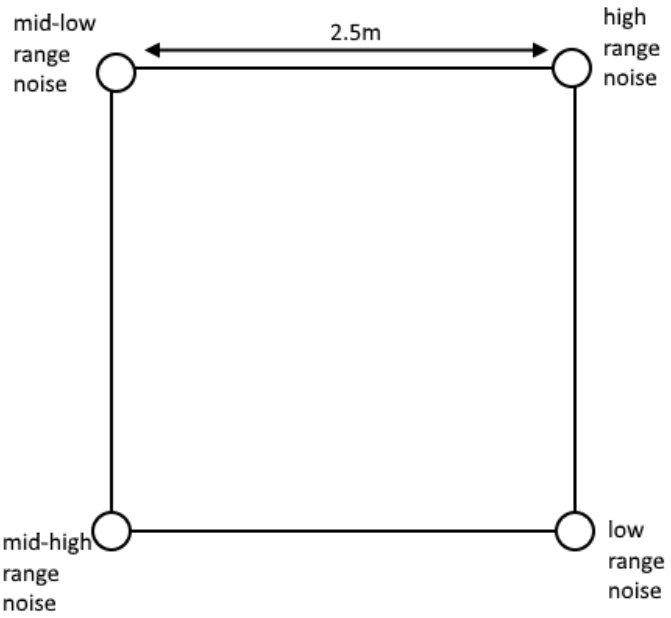
To test this, four speaker-players were loaded with single files of continuous white noise recordings that were then limited by the following filters:

- Low-pass filter at 400Hz and 48Db drop-off.
- High-pass filter at 400Hz and 48Db drop-off; and a low-pass filter at 1000Hz and 48Db drop-off.
- High-pass filter at 1000Hz and 48Db drop-off; and a low-pass filter at 2400Hz and 48Db drop-off.
- High-pass filter at 2400Hz and 48Db drop-off.

These recordings create a set of four bandwidths filled with noise that minimally overlap. The intent was for them to be discernible from one another.

Initially the speakers were clumped together and activated one after the other and in different groupings to see how they were perceived when played together.

The four speakers, now all activated, were then laid out in a square on the ground, 2.5 meters across as shown in the diagram below, to allow for assessment of their qualities in a spatially dispersed situation.



The first part, when the speakers were clumped together, showed that the different bandwidths of noise united easily to create a whole which was difficult to break apart.

In the second part of the experiment, where the sounds were distributed across the floor, the phenomenon of the unification of the sounds was present only when approaching the square from the outside. When a position anywhere inside the shape was taken, the different sound sources were easily discernible from one another, and easier to locate spatially than the sine waves from the previous experiments.

Conclusions

Valuable information was gathered in these short experiments. Which effects work better in small groups of sounds and which in larger ones; which are easier to comprehend in a spatial structure; and what areas in and around the sound sources used are of interest in a composition.

While the experiments carried out were barely a scratch of the surface of what could be learned in this area, they were already enough to give good resources that could be used in compositional efforts of strictly spatial music pieces. The compositions in the next part of this writing attempt to tackle the information gained here and utilize it in a creative manner.

Example Compositions

In this section I will present three compositions that relate to the three experiments in the previous section. Each one attempting to utilize the things learned in the experiments carried out.

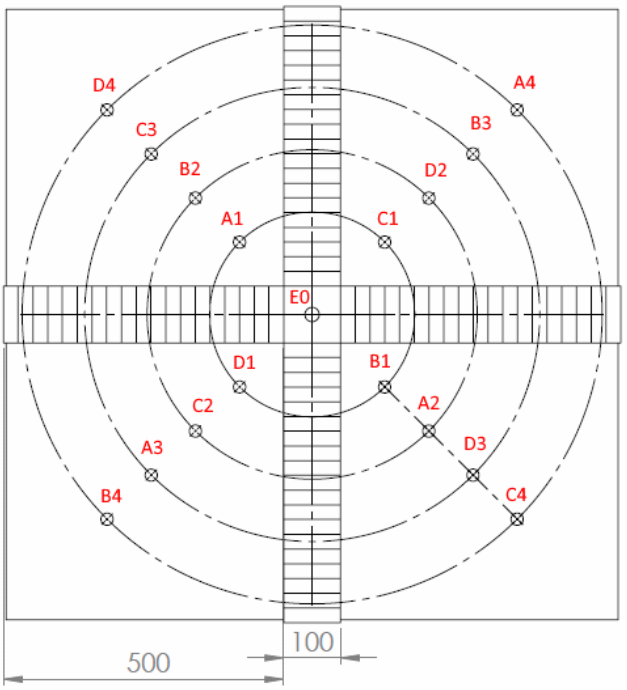
The visual language of the scores/plans for these compositions will need to evolve over time as well. What lies here is an initial attempt at creating clear instructions that allow to recreate the piece regardless of infrastructure used. While this approach may leave some things out which are important for the eventual realization, until I have more empirical experience with this medium, it seemed best to stay in the realm of the abstract, and try to convey the essence of the spatial composition in question rather than the details of its realization. Such details as might be described in future attempts may be: surroundings, construction materials, visual dress, sound source specifications (including directionality, fidelity, sound pressure level, etc.) and more that will become evident through trial and error in realizations to come.

The pieces here are to be considered small scale études in the sense that they wish to show the possibilities of the new creative space of strictly spatial music, and demonstrate the use of knowledge acquired through experimentation. The goal further down the line is to make use of several of these smaller forms and create a larger composition that can truly engulf an experiencer in a large spatial construct that could be traversed in length.

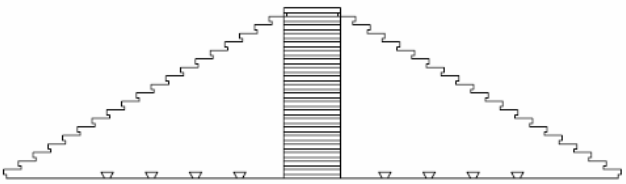
Each sound source is indicated by a small sphere or cone shape marked with a short label. The labels are then shown in a table that describes what each corresponding sound source should emit.

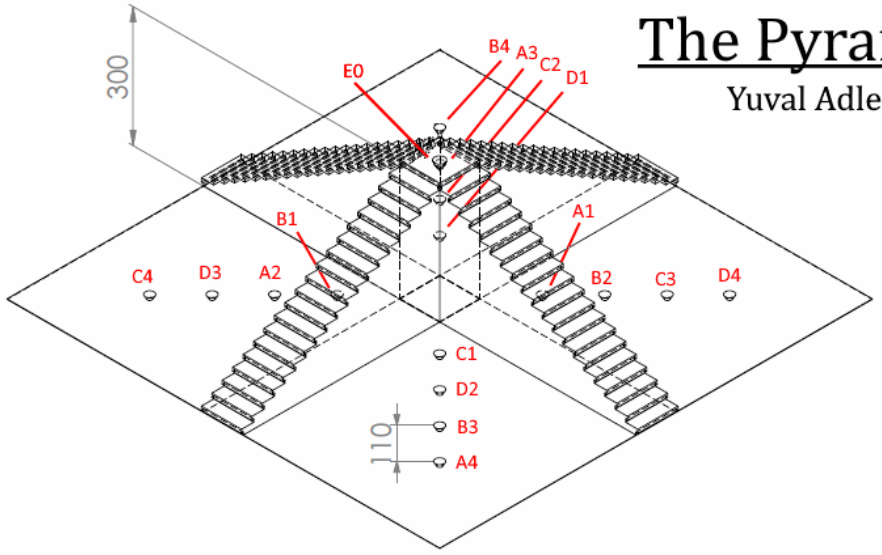
The Pyramid

In *The Pyramid* I split the space into four quadrants using stairs that double as barriers between the spatialized sound sources. The stairs lead up to a point of convergence where all sound sources can be heard. Each group of sound sources constructs a set of harmonics that give rise to a missing fundamental tone of lower frequency. The harmonics of all groups are separated between the quadrants such that they do not create this sensation within each quadrant. Only after walking up to the point of convergence can all sound sources be heard and the phenomena experienced, creating new sounds that were not present when walking around the structure.



Sound Source	Sine Wave Frequency
A1	1000Hz
A2	1100Hz
A3	1200Hz
A4	1300Hz
B1	666.66Hz
B2	800Hz
B3	933.33Hz
B4	1066.66Hz
C1	711.11Hz
C2	800Hz
C3	888.88Hz
C4	977.77Hz
D1	225Hz
D2	300Hz
D3	375Hz
D4	450Hz
E0	337.5Hz



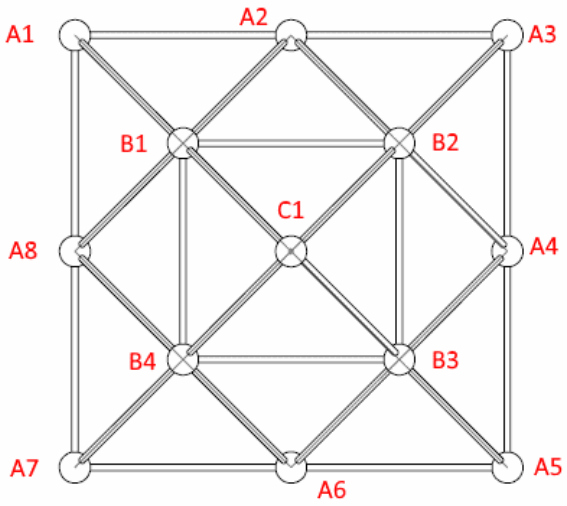


The Pyramid

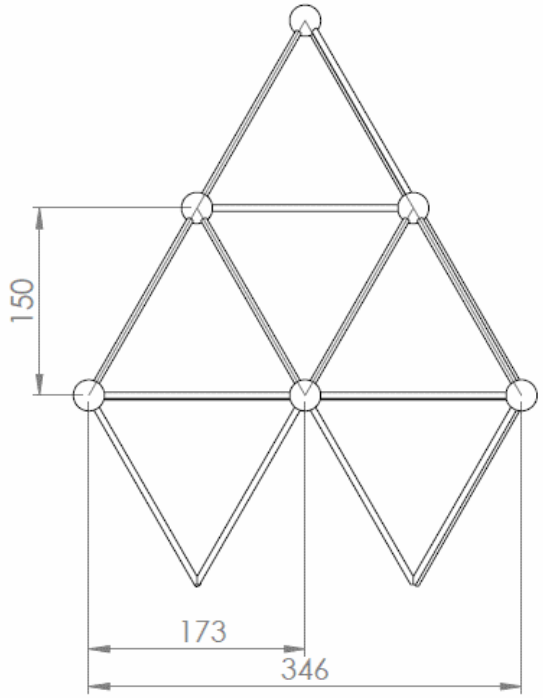
Yuval Adler

The Egg

For *The Egg* I wanted to explore a mass whose components can be pieced apart through “zooming into” the object. From afar, the entire object is heard as a source of broadband noise. When approaching and entering the structure, the individual point sources clarify as banded noise sources, changing the perception of the whole initially met.

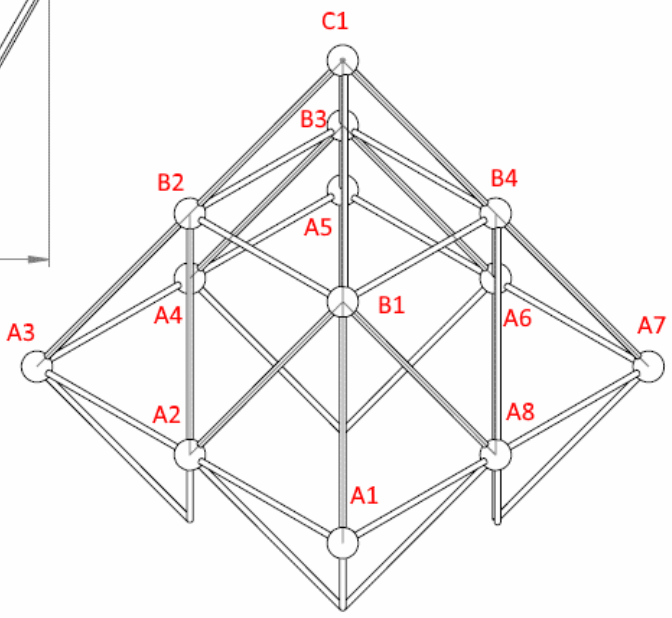


Sound Source	Filtered Noise Frequency Range
A1	10KHz-20KHz
A2	6.4KHz-10KHz
A3	4KHz-6.4KHz
A4	2.5KHz-4KHz
A5	1.5KHz-2.5KHz
A6	1KHz-1.5KHz
A7	800Hz-1KHz
A8	600KHz-800Hz
B1	450KHz-600Hz
B2	350KHz-450Hz
B3	274KHz-350Hz
B4	220KHz-275Hz
C1	20Hz-220Hz



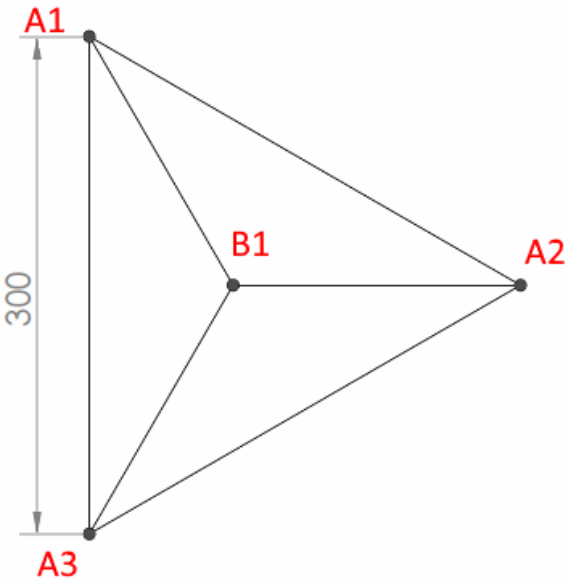
The Egg

Yuval Adler

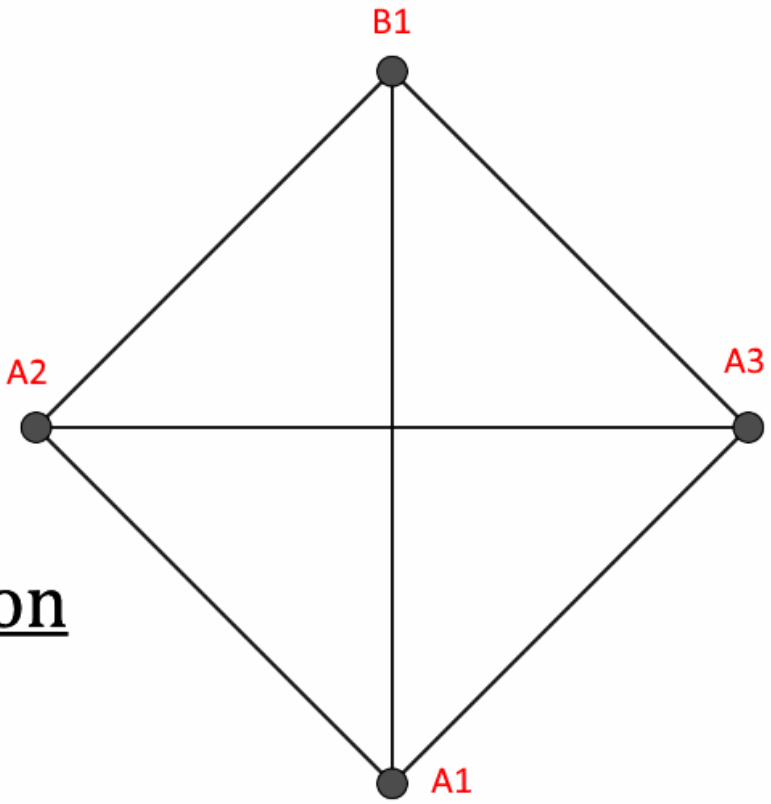


The Tetrahedron

In this work I explored the minimal form of a 3D spatial composition, utilizing a fundamental shape with simple sounds - a tetrahedron and sine tones. The four equidistant sine tones generated create a unique beating pattern for each pair of tones through their differences in frequency.



Sound Source	Sine Wave Frequency
A1	500Hz
A2	501Hz
A3	504Hz
B1	506Hz



The Tetrahedron

Yuval Adler

Discussion

Conclusion

My initial compositional attempts hint that the field is filled with creative possibilities. The experiments shared here have been somewhat limited due to technical restrictions and shortage in time, but have given me an appetite for further experiences within this medium. It will take more work and time to determine whether the excitement these initial attempts created is only a product of their novelty and will fade away after more is done, or whether there is substantial essence to be explored more deeply as work progresses, though I feel that it is the latter which will prove true.

Future Work

Since this is an initial attempt at exploring this creative space of strictly spatial musical composition, the scope of the work done here has been kept very limited. Future work can expand greatly on all fronts. Some ideas follow for what may be done:

- Greater complexity of sounds used.
- Finer control of volume difference between sound sources.
- Controlling the phases of sounds produced in relation to one another.
- Larger works in scope that one might travel inside of for a considerable amount of time.
- Collaborations with other artists that could create performances within the musical space created.
- Collaboration with visual artists and/or architects to co-create compelling structures in the visual and physical sense beyond just the musical.
- Attempting the use of advanced room acoustic properties to create unique sound structures within the physical spaces filled.
- Compositions in virtual spaces that allow us to transcend the human inability to travel in three dimensional space freely.
- Compositions in virtual space that can ignore restrictions of real world acoustics.
- Adding timed structural elements back into the music.